A Promising Future with Aluminum

Having taken a look at the top ranking cars in any given Baja SAE competition, one may notice a common theme: very few suspension setups are composed entirely of steel. While the components that must sustain the highest loads are often steel, other components, such as tie rods, are commonly designed with either aluminum or carbon fiber to reduce the unsprung mass in the system.

Until recently, we have not been able to consider this as an option during the design phase, as we had no way to manufacture aluminum suspension components, and carbon fiber is prohibitively expensive. However, one of our welders, Laurence Lohman ‘17, has begun experimenting with aluminum welding. So far, the results have been promising. With a few pointers from Mahany Welding Supply, he has been able to produce good-looking seams in aluminum plates in a variety of joint geometries. This development opens up quite a few exciting design opportunities for next year, not only for Suspension, but for Usability as well.

- Connor Haddix ‘16, Chief Mechanic
Going into the 2015-2016 design season, one of the major goals for the drivetrain was to reevaluate the gear ratio used in our vehicle in order to improve vehicle torque. We were able to create a simulation of the vehicle acceleration which enabled us to vary different vehicle parameters such as the gear ratio and determine the effect on the acceleration, top speed, and hill climb abilities of the vehicle. From this simulation, we were able to select a new gear ratio to provide our vehicle with better acceleration than in previous years.

In order to validate the results of the simulations for the design competition, we required some method of data collection for the vehicle. To accomplish this, we incorporated the placement of two hall effect sensors in the design of the drivetrain sub-system. One sensor is placed on the engine to record engine rpm and another is inside the gearbox to record the gear rpm. This data will help us to better understand how the CVT is shifting and how the vehicle is accelerating which will enable us to tune the CVT more efficiently and effectively for optimal performance at this year’s competitions.

-Wendy Snyder ’17, Drivetrain PTL

These last few months, the Electronics team has been working on migrating the data logger platform from a relatively slow 16MHz Atmel Atmega328 microcontroller to a much faster 72MHz ARM Cortex-M4 microcontroller. This migration will allow us to increase the rate at which we can poll data from the various sensors throughout the car. In addition to data polling, we can also execute a complex algorithm that combines the positional data of an accelerometer and a gyroscope to properly measure the forces acting upon the car. This positional data is obtained independent of sensor orientation.

-David Gonzalez ’16, Electronics PTL
Determining the causes of last year’s rear bracing failure and modifying the frame accordingly were set as priorities for this year’s design process. Suspension forces were quickly found to be the culprit, and a new model for the rear suspension forces acting on the frame was created in collaboration with the Suspension project team. This model greatly improved the accuracy of our finite element analysis load cases on the frame, and drove the changes made to the rear bracing. These analyses with the new model also prompted the addition of a lateral support member between the rear link mounting points. The changes made with the help of this model should ensure that the vehicle’s frame sees no issues coping with the bumps and jumps at competition this year!

Most of the remaining iterative design changes were focused on weight optimization of the frame: replacing heavy (and expensive) primary members where not required or structurally needed with much lighter secondary members. Numerous finite element analyses were run to verify all design changes with a number of new and updated load cases, including a more accurate rollover load case and a torsional analysis. Specific load cases were also developed for tubes such as the under-seat-members and the driver shoulder restraint mounting members. One major roadblock encountered during the design phase was a slight change in rules wording. Although the rule change seemed insignificant at first, we determined that the entire firewall plane needed to be redesigned because of it. This was achieved with only minor alterations to the rest of the roll cage geometry, although the now more complicated rear roll hoop members were much more difficult to manufacture.

-Alan Grier ’17, Frame PTL

The focus for the Exterior Design team included the modification of design and material usage for the belly pan and body panel, as well as new designs for the hood, number, splash guard and CVT guard. The above designs were simulated using Solidworks and NX and tested with Finite Element Analysis using NX10. Strain and stress testing was performed using the MTS machine in the Hope-man lab with department lab assistant Chris Pratt. We intend to manufacture our molds using the NC router in Rettner Hall, and composites are manufactured in the UR Baja shop. Composite material thermal forming and fiber glass epoxy shaping will also be applied in the manufacturing process.

-Jiacheng Sun, ’17, Exterior Design PTL
One of the interesting issues with vehicles is the fact that the wheels travel at different speeds while turning. This is fine when the wheels are not connected, but becomes an issue with driven wheels. The left and right sides of the output shaft must spin at the same angular velocity, meaning that the tires are both going the same velocity, resulting in one of the tires scrubbing against the ground as the vehicle turns.

Production cars and ATVs negate this through the use of a differential, but installing one on a Baja car would be expensive and impractical. Instead, many teams design the suspension to lift the inner wheel under hard cornering, thus negating the scrub of that wheel. This can be accomplished by installing a very stiff anti-roll bar between the driven suspension components.

This anti-roll bar idea was passed down by a previous suspension team lead and is finally being manufactured and put on the car this year. The process is largely experimental, with the bar designed to accommodate a wide range of torques. Determining which settings work best will be done via vehicle testing. The bar is expected to be most useful for the maneuverability event, where tight cornering is necessary, and will likely be detached for the endurance race to retain independent wheel travel.

- Michael Myers ’16, Suspension PTL

The Pedal subsystem was the only Usability system that warranted a significant design change. Shedding unnecessary weight and increasing the ability to withstand the applied braking force were the two main goals for the pedal subsystem. An additional goal was to reduce the torsional force of the pedal on its components once a braking force was applied. With prior knowledge that an I-beam cross-section is ideal for the general geometry of a brake pedal, this cross-section was maintained in the 2016 brake and accelerator pedals.

In order to accomplish the design goal of weight reduction, the pedal’s material was switched to aluminum. Along with its easier machinability, the aluminum had a total mass reduction of ~0.31 pounds, with the new pedal weighing 0.40 pounds. As finite element analysis was not done properly in the 2015 season on the pedal, this year’s pedal will serve as a basis for upcoming years.

As defined by FSAE, the recommended maximum loading force on a pedal is 400 pounds-force (lbf), applied normal to the footrest. This force accounts for braking in a ‘frantic’ situation, when the driver must apply the pedal in a sudden, extreme manner. With a loading force of 400 lbf normal to the footrest on the pedal and reaction force parallel to the master cylinder of 897 lbf, the 2016 pedal has a factor of safety of roughly 1.5 (see figure). Although half of the design goal, this factor of safety was considered to be satisfactory upon analysis of the maximum stresses on the pedal. The maximum stress on the pedal was found to be in one node of the FEA analysis such that it really would not enact deformation of the pedal.

- Kevin Bonko ’17, Usability PTL
**Design and Sponsorship Day:**

We held our 2nd Annual Design and Sponsorship Day on April 1st. This is an event that we started last year to unveil our completed car to local sponsors, faculty and our fellow students. Additionally, it gives our team a chance to practice both the design and sales presentations before competition.

**Competition Dates:**

Tennessee Tech Competition: April 14-17 (Car #19)
We just returned from this competition and final results should be posted soon! Check http://results.bajasae.net/ for results.

Rochester Competition: June 9-12 (Car #24)

We do our best to keep our Facebook page updated with our progress and results during the competitions. If you’re planning on attending the Rochester competition, please let us know!

**Commencement and Graduation:**

I (and the other seniors on the team) will be graduating on May 15. The next newsletter you read will be sent by a different president! I hope you’ve enjoyed reading these as much as I’ve enjoyed working on them!

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